Carbon Cycle Science USGCRP Initiative

Context of the Program Element

Scientific Rationale

The need to understand how carbon cycles through the Earth system is critically important to our ability to predict future climate change.

- **Carbon dioxide is one of the most important gases in the atmosphere affecting the radiative balance of the earth.**
- **About half of the CO2 released by human activities remains in the atmosphere, and the rest is taken up by the ocean and terrestrial biosphere.**

The carbon cycle must be studied as an integrated system, as the atmospheric concentrations depend on the behavior of the other two reservoirs

Context of the Program Element

Scientific Rationale *(cont.)*

Current projections of atmospheric carbon dioxide concentrations assume that the carbon cycle will continue to operate as it has in the past few decades. However, there is increasing evidence that this may not be the case:

- The storage capacity of terrestrial ecosystems is unknown
- Reorganizations of the physical climate system may reduce uptake of carbon by the ocean.

Context of the Program Element

***Scientific Rationale** (cont.)*

Although it is the carbon dioxide in the atmosphere which affects the radiative balance of the atmosphere and climate change, carbon cycles throughout the the ocean, atmosphere and land biosphere.

- The carbon cycle must therefore be studied as an integrated system, as the atmospheric concentrations depend on the behavior of the other two reservoirs.
- Techniques used to study one reservoir can also provide information on carbon fluxes to the other reservoirs

Context of the Program Element

Policy Relevance

Need for Information

- Unbiased scientific knowledge and analysis must be provided and effectively communicated to inform a political debate marked by sharp controversy.
- Policy debates have demonstrated the need for a scientific basis for evaluating potential carbon sequestration strategies and measurement of net emissions from major regions of the world.

Context of the Program Element

Scientific readiness:

- Significant advances in our ability to measure and model carbon fluxes.
- Major change in our thinking about the role of the terrestrial biosphere
  - Terrestrial biosphere can be a significant sink and not only a large source.
  - Human activities may be significantly enhancing carbon uptake in some regions.

Recommendations:

- NRC Pathways Report called for more coherent and integrated carbon cycle research
- Scientific Community ask for a comprehensive and integrated interagency program

Overview of Carbon Cycle Science Initiative

- **The carbon cycle program will provide the scientific foundation for estimating the capacity of ecosystems on land and in the ocean to sequester and store the considerable quantities of carbon dioxide anticipated from human activities in the future.**

- **The program will identify and quantify regional to global scale sources/sinks for carbon dioxide and understand how these sources and sinks will function in the future, providing essential information for future climate predictions.**

Carbon Cycle Science Interagency Working Group

Elvia Niebla, Forest Service <eniebla/wo@fs.fed.us>
Lisa Dilling, NOAA <dilling@ogp.noaa.gov>
Diane Wickland, NASA <dwicklan@mail.hq.nasa.gov>
Janet Campbell, NASA <jcampbe1@mail.hq.nasa.gov>
John Ranson, NASA <jranson@hq.nasa.gov>
Roger Dahlman, DOE <Roger.Dahlman@oer.doe.gov>
Jerry.Elwood, DOE <Jerry.Elwood@oer.doe.gov>
Don Rice, Chemical Oceanography, NSF <drice@nsf.gov>
Anne-Marie Schmoltner, Atmospheric Chem., NSF <aschmolt@nsf.gov>
Patrick Neale, Smithsonian <NEALE@SERC.SI.EDU>
Marilyn Buford, Forest Service <Buford_Marilyn/wo@fs.fed.us>
Bryce Stokes, Forest Service <bstokes/wo@fs.fed.us>
Richard Birdsey, Forest Service <Birdsey_Richard/ne@fs.fed.us>
Wanda Ferrell, DOE <wanda.ferrell@science.doe.gov>
Joel Brown, NRCS <joelbrow@nmsu.edu>
Jeri Berc, NRCS <Jeri_Berc-NRCS@mailoce.oce.usda.gov>
Bruce Kimball, ARS <BAK@ars.usda.gov>
Michael Jawson, ARS <MDJ@ars.usda.gov>
Elliott Spiker, USGS <espiker@usgs.gov>

Goals and Objectives

Overall Goal

To understand, monitor, observe and model the carbon cycle as an integrated system in order to provide critical scientific information on the fate of carbon dioxide in the environment and how the cycling of carbon may change in the future.

Long-term questions

- What has happened to the carbon dioxide that has already been emitted by human activities?
- What will be the future atmospheric carbon dioxide concentration resulting from past and future emissions?

Goals and Objectives

Key research challenges

- **Northern Hemisphere terrestrial carbon sinks:** Establish accurate estimates of the location, magnitude, and sustainability of Northern Hemisphere terrestrial carbon sinks, including understanding its interannual variability, spatial distribution and sensitivity to climate change.
- **Oceanic carbon sink:** Establish accurate estimates of the oceanic carbon sink, including understanding its interannual variability, spatial distribution and sensitivity to climate change.
- **Land use change and forestry:** Establish accurate estimates of the impact of historical and current land use change, timber harvest, and deforestation on carbon sources and sinks.

Goals and Objectives

Key research challenges (cont.)

- **Enhanced carbon sequestration:** Develop the scientific basis for evaluating potential management strategies to enhance carbon sequestration.
- **Future atmospheric carbon concentrations**: Improve projections of future carbon dioxide atmospheric concentrations by incorporating improved understanding of the stability/integrity of sources and sinks and appropriate carbon cycle-climate feedbacks into global climate and carbon cycle models.

Interagency Coordination and Interdependencies

Future interagency coordination mechanisms being considered -

- Interagency Working Group
- Scientific advisory committee (SAC)
- Joint RFPs
- Joint research projects with common, integrated plans (but tasks may be selected through separate mechanisms)
- Joint decision-making and/or priority setting for key research sites, infrastructure, and data sets
- Focused workshops and symposia
- Model intercomparison
- Cooperation in the development, integration, and intercomparison of key data sets
- Model intercomparisons

Relevance

- Variability and major changes in carbon cycle behavior are not represented in climate models-- predictions of future CO_2 levels are likely inaccurate

- IPCC 2000 will have a special report on carbon sources and sinks, and will likely address the need to understand the carbon cycle in a dynamic way

Relevance cont.

- Both corporate and policy decision-makers are acting to address atmospheric CO_2, even before a Protocol is agreed upon

- Maximizing sinks, either artificially or by taking advantage of the natural cycle, requires knowledge of location, magnitude and responsible processes

Relevance cont.

- As policies are enacted to maximize sequestration on land and in the ocean on a regional basis, the assessment process may begin to require regional carbon cycle information

Priorities of USGCRP Carbon Cycle Science Initiative - FY 2000

- Produce State of Science Report
- Implement Integrated Observation, Research and Modeling on North American Terrestrial Carbon Sink
- Synthesis of Global Ocean Carbon Dioxide Data
- Improve Research on Processes Controlling Carbon Exchange and Storage
- Improve Long-Term, Integrated Carbon Measurements in Atmosphere, Ocean and land Ecosystems

U.S. Government Agency Priorities in FY 2000

- *DOE -- Flux Measurements (Joint Agency)*
  - Strategic Plan for Eddy Co-Variance Sites
  - 10 Additional Flux Measurement Sites
  - Expand Aircraft Flux Measurements
- *DOE -- Manipulation Experiments - Terrestrial Ecosystems*
  - Place Current Program on Sound Operational Foundation
  - Focus on Below Ground Processes
  - Improve Estimates of Carbon Sequestration
- *DOE -- Ocean Research*
  - Synthesis of Carbon Dioxide Data (Joint with NOAA)
  - Linkage Between Carbon and Nitrogen Cycle Using Molecular Biology Tools

U.S. Government Agency Priorities in FY 2000 (cont.)

- ***NOAA (Interagency) -- Magnitude, Location of N. Hemisphere Terrestrial Carbon Sink***
  - **Design Integrated Plan for N. Hemisphere Carbon Research**
  - **Aircraft Campaign Linked to Tall Towers**
- ***NOAA -- Ocean Carbon Sink***
  - **Understand Controls on Air-Sea Flux**
  - **Develop Autonomous Sensors for Monitoring**
  - **Synthesis of Carbon Dioxide Data (Joint with DOE)**
- ***NOAA -- Modeling***
  - **Carbon Cycle Modeling Consortium**
  - **New Coupled Carbon Cycle - Climate Model**

U.S. Government Agency Priorities in FY 2000 (cont.)

- ***USGS -- Landscape Dynamics and Vegetation Change***
  - **Data Bases for Landscape Modeling**
  - **Regional, Global Scale Vegetation Analysis**
- ***USGS -- Biogeochemical Cycling***
  - **Carbon and Nutrients in Soils, Rivers and Lakes**
  - **Carbon Sequestration in Sediments**
- ***USGS -- Carbon in Alaskan Landscapes***

U.S. Government Agency Priorities in FY 2000 (cont.)

- ***NASA -- Observations from Space***
  - **Land-Cover Change**
  - **Ocean Color and Synoptic Physical Parameters**
- ***NASA -- Field Campaigns and Modeling***
  - **Estimate Terrestrial Carbon Sources and Sinks at Regional Scale**
  - **Ecosystem Modeling**

U.S. Government Agency Priorities in FY 2000 (cont.)

- ***U.S. Forest Service -- Carbon Inventory and Life Cycle Analysis***
  - **Quantify Carbon Sources, Sinks and Fluxes**
  - **Relate Carbon Budgets to Land-Use Change**
  - **Extend Life Cycle of Wood products**
- ***U.S. Forest Service -- Increase Carbon Storage in Forests***
  - **Reforestation, Afforestation and Vegetation Management**
  - **Sequestration in Woody Biofuels**
  - **Soil Carbon Sequestration**

U.S. Government Agency Priorities in FY 2000 (cont.)

- ***NSF -- Synthesis and Modeling Project***
  - **Regional Processes and Components of Marine Carbon Cycle - North Atlantic, Equatorial Pacific and Arabian Sea**
  - **Air-Sea Exchange, Carbon Cycling in Upper Ocean and Export to Abyss**
- ***NSF -- Biogeochemical Cycles and Ecological Interactions of Marine***
- ***Carbon Cycle***
  - **Interconnected Cycles of Nitrogen, Silicon and Iron**
  - **Evaluate IronEx Studies**

U.S. Government Agency Priorities in FY 2000 (cont.)

- ***USDA/ARS -- Monitoring and Data Base Development***
  - **Monitor Changes of Carbon Balance in Forage and Rangeland Systems**
  - **Develop Data Bases for Process Models and Balance Sheet Analysis**
    - **Greenhouse Gas Emissions**
    - **Carbon Sequestration**
- ***USDA/ARS -- Model Development and Validation***
  - **Reduced Form Models to Predict Carbon Carbon Change as Function of Management Practice**
  - **Process Models of Soil Carbon Change**
- ***USDA/ARS -- Process Research***
  - **Residue/Microbial Transformation of Carbon**
  - **New Technology for Measuring Fluxes**
  - **New Technology for Measuring Methane Emissions**

Carbon Cycle Science Plan Working Group Members

Scott Denning	Colorado State University
Bill Easterling	Pennsylvania State University
Chris Field	Carnegie Institution
Inez Fung	University of California, Berkeley
Ralph Keeling	University of California, San Diego
Jim McCarthy	Harvard University
Steve Pacala	Princeton University
Mac Post	Oak Ridge National Laboratory
Jorge Sarmiento	Princeton University, Co-Chair
Eileen Shea	East-West Institute, Hawaii
Dave Schimel	NCAR
Eric Sundquist	US Geological Survey
Pieter Tans	NOAA/ CMDL
Ray Weiss	Scripps Institution of Oceanography
Steve Wofsy	Harvard University, Co-Chair
Jim Yoder	University of Rhode Island